Guest Editorial Special Issue on Edge-Cloud Interplay Based on SDN and NFV for Next-Generation IoT Applications

WITH significant and continuing advances in information and communication technologies, the Internet of Things (IoT) will play an increasingly important role in domains, such as healthcare, transportation, finance, and energy. In an IoT system, billions of devices (e.g., sensors, wearables, and smart appliances) are connected to the global network infrastructure, and one associated phenomenon is the generation of a large volume of data. Apart from data volume, the velocity, variety, and veracity of these data will pose a significant burden on conventional networking infrastructures. However, as sensor and fifth-generation (5G) cellular technologies advance, so will the pervasiveness of IoT deployment. Parallel to this trend, cloud computing has been integrated with IoT in order to address limitations in existing IoT networks (e.g., storage and computing resources), and examples include Google cloud dataflow and Amazon IoT. However, cloud-centric IoT solutions may not be suited for delay-sensitive and computationally intensive applications, for example, due to resource availability, end-to-end latency, bandwidth, etc. Increasingly, large-scale IoT deployments demand high connectivity, interoperability, and orchestration which are necessary for minimizing latency and maximizing throughput. This highlights the importance of a distributed computing platform that can support the interactions between IoT and cloud computing systems.

Hence, there has been a shift to edge computing, where computation and storage resources are moved closer to the proximity of data sources. However, a large number of migration between edge and cloud impose communication delays, as well as resulting in latency, bandwidth, and inefficient energy consumption issues. Thus, there have been attempts to explore the potential of network softwarization paradigms, such as software-defined network (SDN) and network function virtualization (NFV). SDN makes the network programmable to deliver services and applications with greater agility and cost effectiveness. NFV, on the other hand, provides network functionality, while enabling better provisioning of network resources. Thus, SDN and NFV will potentially improve the flexible deployment of networks while enabling programmability, reconfigurability, and multitenant capability, if used in conjunction. Furthermore, things in next-generation IoT systems are expected to be extremely heterogeneous in terms of platforms, resources, and connectivity. As a result, the amalgamation of SDN and NFV in edge-cloud interplay is, undeniably, promising in improving the Quality of Service (QoS) for complex IoT-driven applications. However, there are challenges, such as runtime service deployment, resource scheduling, security, energy management, remote orchestration, and lack of aggregation/distribution strategies remain, which need to be addressed for the successful deployment of such paradigms.

Thus, this special issue proposes to present the state-of-the-art approaches, methodologies, and key technologies, in the design, development, deployment, and innovative use of SDN and NFV for edge-cloud integration in next-generation IoT infrastructures. We received over 115 submissions, and each submission was assigned to at least three reviewers with relevant subject matter experts. The 42 articles that were eventually accepted for inclusion in this special issue went through at least two rigorous rounds of review. We will now briefly introduce the accepted articles and highlight their main contributions.

In "Differentially private tensor train decomposition in edge-cloud computing for SDN-based Internet of Things," the authors proposed a differentially private tensor computing model to address the problems of data representation, data mining, and privacy protection in SDN-based IoTs.

In "Interaction of edge-cloud computing based on SDN and NFV for next generation IoT," the authors discussed multiattribute decision making of the mobile-edge computing migration strategy based on NFV and SDN techniques.

In "Real-time fault detection for IIoT facilities using GBRBM-based DNN," the authors constructed a framework of self-driving networks for edge industrial IoT networks.

In "An efficient energy cost and mapping revenue strategy for interdomain NFV-enabled networks," the authors proposed an energy cost model and resource allocation strategy in interdomain NFV-enabled networks.

In "Exploring deep learning models for overhead view multiple object detection," the authors focused on the detection of multiple objects for overhead view by leveraging two convolutional neural network architectures.

In "THP: A novel authentication scheme to prevent multiple attacks in SDN-based IoT network," the authors presented a secure authentication scheme for SDN to defend against

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shoulder-surfing attacks, recording screen attacks, and smudge attacks.

In "Low-latency and resource-efficient service function chaining orchestration in network function virtualization," the authors proposed a breadth-first search-based algorithm for efficient service function chain provisioning and improving the overall utilization of the physical network.

In "DPTO: A deadline and priority-aware task offloading in fog computing framework leveraging multilevel feedback queueing," the authors constructed a delay-dependent priority-aware offloading strategy for scheduling and processing the tasks based on multilevel feedback queuing.

In "Context-aware object detection for vehicular networks based on edge-cloud cooperation," the authors designed a deep-learning-based object detection method to deal with the high mobility and high dynamic environments of vehicular networks.

In "A cloud–MEC collaborative task offloading scheme with service orchestration," the authors introduced an offloading scheme for big data transmission and processing load.

In "Human-like hybrid caching in software-defined edge cloud," the authors proposed a human-like caching architecture based on neural network and reinforcement learning, which effectively handles the delay requirement for content requests in the IoT environment.

In "AI agent in software-defined network: Agent-based network service prediction and wireless resource scheduling optimization," the authors presented a mobile agent system, which uses AI agents deployed at different levels of SDN to complete network service prediction and resource scheduling functions.

In "Local differential privacy for deep learning," the authors developed a distributed privacy-preserving mechanism to control privacy leakage in convolutional neural network models.

In "AdaptFlow: Adaptive flow forwarding scheme for software-defined industrial networks," the authors suggested an application-specific flow classification scheme wherein incoming traffic is differentiated using self-organized mapping followed by a B+tree-based flow table management.

In "ESMLB: Efficient switch migration-based load balancing for multicontroller SDN in IoT," the authors investigated the load imbalance problem in SDN and proposed a multicriteria decision technique to select a target controller.

In "Integrating NFV and ICN for advanced driver-assistance systems," the authors proposed a content sharing architecture where ICN is used to achieve multiuser sharing mode and NFV is introduced to allocate resources for big data computing and transmitting.

In "SDN-powered humanoid with edge computing for assisting paralyzed patients," the authors presented an assistive system for paralyzed patients using a humanoid powered by universal software radio peripheral and edge computing.

In "Complexity and algorithms for superposed data uploading problem in networks with smart devices," the authors proposed a decentralized device-to-device communication system in order to minimize the total energy consumption of uploading superposed data.

In "APIS: Privacy-preserving incentive for sensing task allocation in cloud and edge-cooperation mobile Internet of Things with SDN," the authors proposed an auction-based privacy-preserving scheme, which maximizes the sensing utility while controlling the privacy leakage in the mobile IoT.

In "Joint trajectory-resource optimization in UAV-enabled edge-cloud system with virtualized mobile clone," the authors presented a UAV-enabled edge cloud system, where UAV works as MEC server and interplays with the central cloud to provide computation services to the ground terminals while minimizing energy consumption.

In "A novel load balancing and low response delay framework for edge-cloud network based on SDN," the authors designed a service orchestration and data aggregation framework based on SDN, which aims to reduce data redundancy and services response time for data transmission.

In "Software-defined edge computing (SDEC): Principle, open IoT system architecture, applications and challenges," the authors designed an SDEC-based open IoT system architecture, which decouples upper level IoT applications from the underlying physical edge resources and builds dynamically reconfigurable smart edge services.

In "Wireless virtualization architecture: Wireless networking for Internet of Things," the authors designed a three-layer game-theoretic wireless virtualization architecture to support wireless networking in emerging IoT applications.

In "Two-stage offloading optimization for energy–latency tradeoff with mobile edge computing in maritime Internet of Things," the authors presented a joint optimal offloading strategy for large-scale maritime communication, which combines with mobile-edge computing to provide efficient computing capability.

In "Alleviating heterogeneity in SDN-IoT networks to maintain QoS and enhance security," the authors proposed a high-level SDN-IoT architecture, which transforms the heterogeneous controllers into a group of homogeneous controllers in order to maintain QoS and strengthen the security of a network with interconnected IoT nodes.

In "Reinforcement-learning- and belief-learning-based double auction mechanism for edge computing resource allocation," the authors presented a double auction-based MEC-IoT resource trading market, in which IoT devices can offload their tasks to MECs for higher speed data processing and shorter response time.

In "Communication-efficient federated learning for wireless edge intelligence in IoT," the authors adapted a popular federated learning algorithm with Adam optimization and compression in order to reduce computational overhead and facilitate more efficient distributed edge-based computing and distributed learning.

In "Toward big data processing in IoT: Path planning and resource management of UAV base stations in mobile-edge computing system," the authors investigated the problem of big data processing in IoT environments with UAV serving as base stations. They proposed an online edge processing scheduling algorithm based on Lyapunov optimization to address the problem of dynamic path planning.

In "Trusted cloud-edge network resource management: DRL-driven service function chain orchestration for IoT," the authors presented a service function chain orchestration architecture based on the consortium blockchain and deep reinforcement learning (DRL), to realize trusted and auto-adjusted resource sharing.

In "IoT-based context-aware intelligent public transport system in a metropolitan area," the authors designed an intelligent public transportation system based on emergent intelligence technique which intends to support commuters and transport authority in taking dynamic decisions.

In "Toward optimal hybrid service function chain embedding in multiaccess edge computing," the authors investigated how to optimize the provisioning of hybrid service function chains (h-SFC) that use different service functions in upstream and downstream directions. An optimization problem was formulated that optimally embeds a given h-SFC onto the substrate network.

In "Smart collaborative tracking for ubiquitous power IoT in edge-cloud interplay domain," the authors proposed a Monte Carlo estimation method of target tracking by investigating advanced parameter prediction skills and improved particle filter approaches.

In "Efficient and provably secure multireceiver signcryption scheme for multicast communication in edge computing," the authors introduced a new multimessage and multireceiver signcryption scheme, which is based on the elliptic curve cryptography and certificateless public-key cryptography and can achieve receiver anonymity.

In "On the lifetime of asynchronous software-defined wireless sensor networks," the authors formulated a mathematical model to compute the maximum network lifetime and accordingly proposed a multichannel operation and transmit power control to reduce the effect of overhearing in asynchronous networks.

In "SDN-enabled network coding-based secure data dissemination in VANET environment," the authors presented a reliable and secure data dissemination architecture which exercises the concept of SDN by incorporating network coding with multigeneration-mixing functionalities.

In "Waiting time minimized charging and discharging strategy based on mobile edge computing supported by software-defined network," the authors proposed a mobile-edge-computing-enabled charging and discharging scheme for electric vehicles, which aims to minimize the maximal waiting time of the charging stations.

In "An IoT Platform-as-a-Service for NFV-based hybrid cloud/fog systems," the authors proposed a novel IoT PaaS architecture for NFV-based hybrid cloud/fog system, which automates the provisioning of IoT applications over cloud and fog resources.

In "Energy-efficient provisioning for service function chains to support delay-sensitive applications in network function virtualization," the authors proposed an energy-aware routing and adaptive delayed shutdown mechanism for improving the energy efficiency of the substrate network and delay experience of virtual network functions.

In "FESDA: Fog-enabled secure data aggregation in smart grid IoT network," the authors designed a fog-based privacy-preserving data aggregation scheme for smart grids, where a modified version of the Paillier cryptosystem is used to achieve data privacy and the false data insertion problem was tackled by filtering out the data inserted by attackers.

In "Blockchain-enabled distributed security framework for next-generation IoT: An edge-cloud and software-defined network-integrated approach," the authors presented a security framework that incorporates the use of blockchain technology and integrates an SDN-based highly programmable IoT network to authorize the identification of attacks.

In "5G NFV-based tactile Internet for mission-critical IoT services," the authors presented a human perception resolution and the network cost-based utility function model for evaluating the performance of the NFV-based tactile Internet and enable mission-critical IoT services.

In "*Dyme*: Dynamic microservice scheduling in edge computing enabled IoT," the authors proposed a dynamic microservice scheduling scheme for MEC-enabled IoT to maximize network throughput, while providing optimal QoS level to end users. The authors also presented a microservice prioritization scheme to maximize the satisfaction level of both end users and microservices in the edge platform.

We would like to express our sincere gratitude to all the authors who submitted their valuable contributions to this special issue, as well as to all the experts who participated in the review process and provided suggestions to help the authors improve their research. The Guest Editors are also immensely grateful to the former Editor-in-Chief, Prof. Xuemin (Sherman) Shen, for the opportunity to organize this special issue and the current Editor-in-Chief, Prof. Honggang Wang, for his unwavering support and guidance in preparing and finalizing this editorial. Also, we would like to thank the Editorial Staff for their support leading to the publication of this special issue. We sincerely hope that this special issue will contribute to the body of knowledge.

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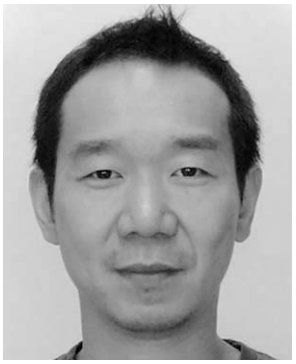

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